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भारतीय मानक

बाल स्क्रू

भाग 1 शब्दावली और अभिनाम

Indian Standard

BALL SCREWS

PART 1 VOCABULARY AND DESIGNATION

ICS 01.040.25; 25.060.99

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

October 2000 **Price Group 4**

Machine Tool Elements and Holding Devices Sectional Committee, BP 02

NATIONAL FOREWORD

This Indian Standard (Part 1) which is identical with ISO 3408 - 1 : 1991 'Ball screws — Part 1 : Vocabulary and designation' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Machine Tool Elements and Holding Devices Sectional Committee and approval of the Basic and Production Engineering Division Council.

This standard deals with ball screws used on machine tools and is being issued in the following parts:

Ball screws –

Part 1 Vocabulary and designation
Part 2 Nominal diameters and nominal leads — Metric series
Part 3 Acceptance conditions and acceptance tests
Part 4 Ball screw axial rigidity
Part 5 Distribution of static and dynamic loads and operational life

At the moment, only standards on Parts 1, 2 and 3 are being issued whereas standards in regard to Parts 4 and 5 will be issued as soon as the work on them is completed at the International level.

The text of the ISO Standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

c) The French text appearing in the International Standard has been deleted because of obvious reasons.

In the adopted standard, reference appears to one International Standard for which Indian Standard also exists. The corresponding Indian Standard which is to be substituted in its place is listed below along with its degree of equivalence for the edition indicated.

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 286-1 : 1988 ISO system of limits and fits — Part 1 : Bases of tolerances, deviations and fits	IS 919 (Part 1) : 1993 ISO system of limits and fits : Part 1 Bases of tolerances, deviations and fits (*second revision*)	Identical

Indian Standard

BALL SCREWS

PART 1 VOCABULARY AND DESIGNATION

1 Scope

This part of ISO 3408 establishes the vocabulary for ball screws (see figure 1).

NOTE — The actual design need not necessarily correspond to that shown in figure 1.

It also specifies the various elements which designate ball screws.

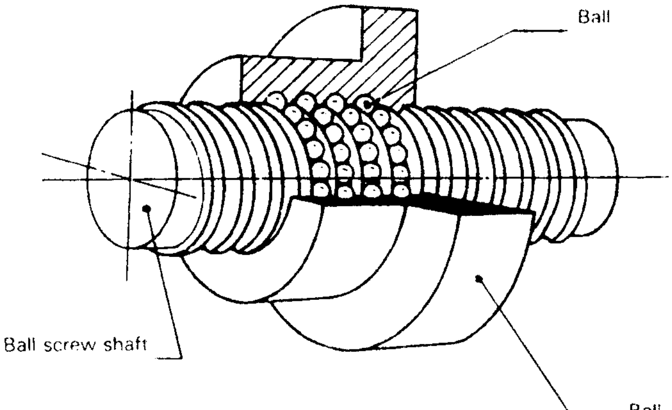


Figure 1 — Ball screw

2 Component terms and definitions

The components of ball screws are shown in figure 2 and are defined below.

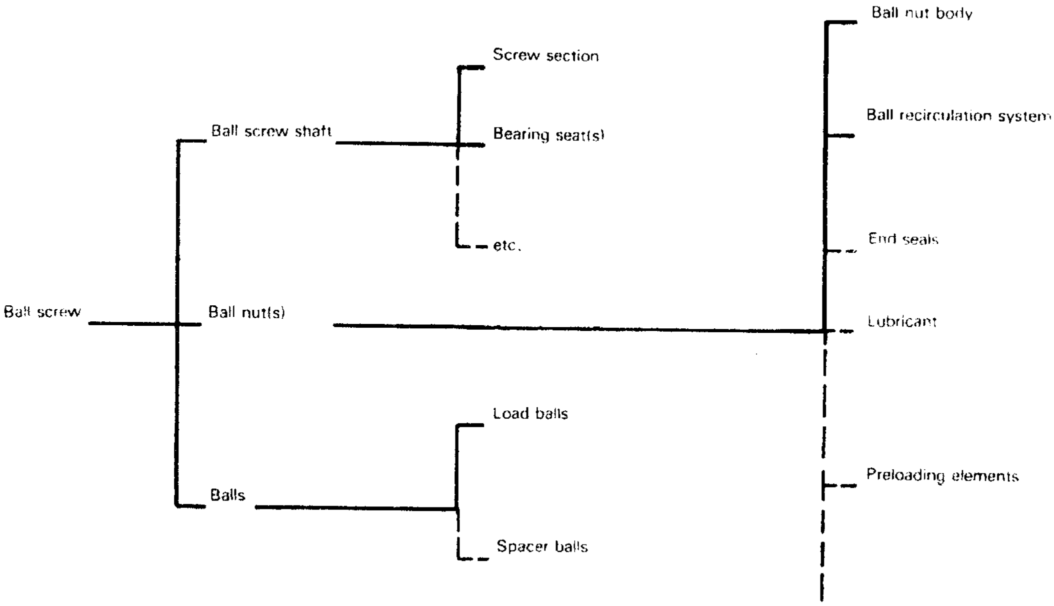


Figure 2 — Components of a ball screw

2.1 ball screw : An assembly comprising a ball screw shaft, ball nut(s) and balls, and which is capable of converting rotary motion to linear motion and vice versa. The rolling elements of the assembly are balls.

NOTES

1 Depending on the application, ball screws are designed either with backlash or without backlash (preloaded).

2 To meet individual requirements five standard tolerance grades 1, 3, 5, 7 and 10 are available. The tolerances for the travel deviation are in accordance with the standard tolerance grades IT1, IT3, IT5, IT7 and IT10 of ISO 286-1 : 1988, *ISO system of limits and fits — Part 1 : Bases of tolerances, deviations and fits.*

Usually standard tolerance grades 1 to 5 are preloaded, and grades 7 and 10 are not preloaded.

2.1.1 positioning ball screw (type P) : Ball screw used for precision positioning which enables the indirect measurement of axial travel from the angle of rotation and the lead, without backlash (preloaded).

2.1.2 transport ball screw (type T) : Ball screw the travel of which is measured directly by a separate measuring system independent of the angle of rotation and lead of the ball screw.

NOTE — Usually tolerance grades 7 and 10 are used, but for special applications where high performance in torque variation (smooth running) is required, tolerance grades 1 to 5 may be used also.

2.1.3 single-start ball screw : Ball screw in which the lead is equal to the pitch.

2.1.4 multiple-start ball screw : Ball screw in which the lead is an integer multiple of the pitch.

2.2 ball screw shaft : A cylindrical shaft on which is cut one (or more) helical track(s).

2.3 ball nut : The ball nut body assembled with a recirculation system, end seals, and nut accesories.

2.3.1 ball nut body : Ball nut without balls, a recirculation system, and nut assessories.

2.3.2 recirculation nut : Ball nut comprised of one (or more) continuous closed bath(s) [circuit(s)] of recirculating balls.

2.3.3 recirculation system : A system comprising one (or more) continuous closed path(s) [circuit(s)] of recirculating balls.

2.3.4 end seals : Closure elements attached to the ball nut body and in sliding contact with the ball screw shaft in a manner such that foreign objects are inhibited from entering the ball nut and/or partial retention of the lubricant is provided.

2.4 Ball

2.4.1 load ball : A ball which carries a portion of the load.

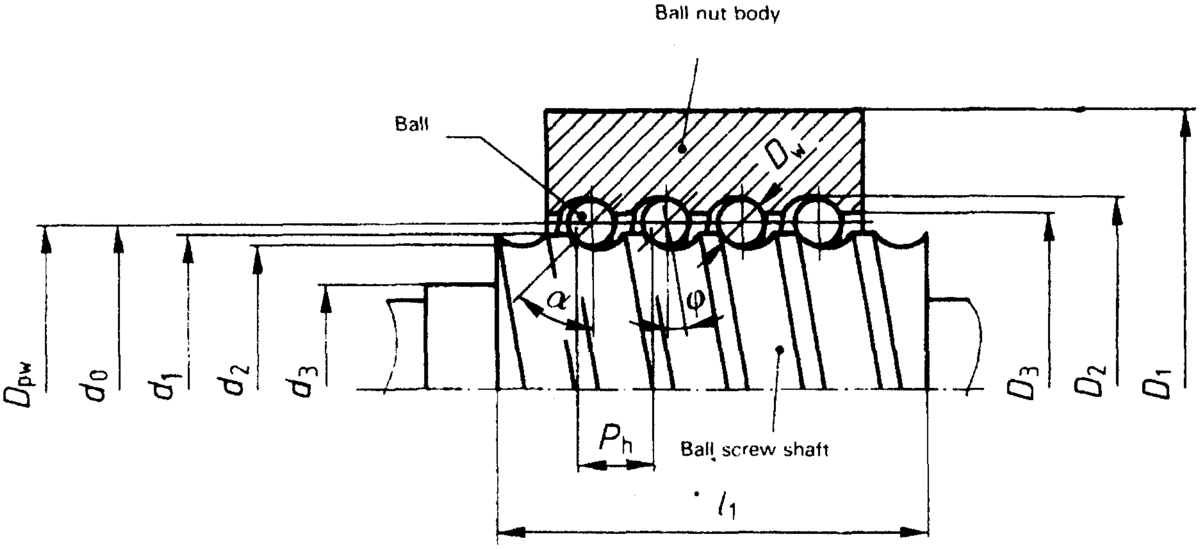
2.4.2 spacer ball : A ball, smaller than a load ball, and which is non-load carrying.

3 Geometrical terms and definitions

3.1 Geometrical symbols relating to the dimensions of a ball screw (see figure 3)

3.2 Terms and definitions

3.2.1 nominal diameter, d_0 : value used for designation (without tolerance).



d_0 = nominal diameter
d_1 = ball screw shaft outer diameter
d_2 = ball screw shaft root diameter
d_3 = journal diameter
D_1 = ball nut body outer diameter
D_2 = ball nut body root diameter
D_3 = ball nut body internal diameter
D_{pw} = pitch circle diameter
D_w = ball diameter
l_1 = thread length
P_h = lead
α = nominal contact angle
φ = lead angle

Figure 3 — Dimensions of a ball screw

3.2.2 pitch circle diameter, D_{pw} **:** The diameter of the cylinder containing the centres of the balls which are in contact with the screw shaft and the ball nut body at the theoretical contact points. (See figure 3.)

NOTE — The pitch circle diameter is generally but not always considered to be equivalent to the nominal diameter of the ball screw.

3.2.3 ball track : A specially designed helical groove in the ball nut body or ball screw shaft of a ball screw which transmits the load reaction between the ball nut body and the ball screw shaft through the balls. (See figure 4.)

3.2.3.1 Groove

3.2.3.1.1 gothic (ogival) groove : A ball track whose normal cross-section is in the form of a gothic arch.

3.2.3.1.2 round groove : A ball track whose normal cross-section is in the form of an arc of a circle.

3.2.3.2 conformity, f_r **:** Ratio of the ball track radius of the ball screw shaft, r_s, or of the ball nut body, r_n, to the ball diameter, D_W (see figure 4):

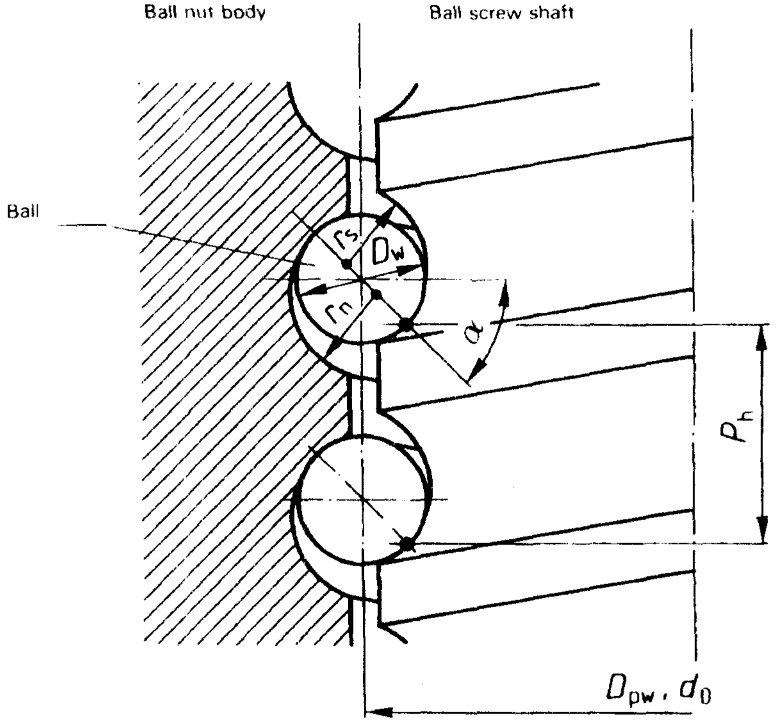


Figure 4 — Ball track

$$f_{rs} = \frac{r_s}{D_w} \text{ or } f_{rn} = \frac{r_n}{D_w}$$

where the subscripts s and n denote the ball screw shaft and the ball nut body respectively.

3.2.3.3 nominal contact angle, α : The angle between a plane perpendicular to the ball screw shaft axis and the resultant of the forces transmitted by a ball track to a rolling element.

3.2.3.4 backlash [axial play], s_a : Total free axial displacement between the ball nut body and the ball screw shaft when there is no rotation between the two components.

3.2.3.5 radial play, s_r : Total free radial displacement between the ball nut body and the ball screw shaft.

3.2.4 travel, l : The axial displacement of the ball screw shaft or the ball nut when rotating the ball screw shaft or the ball nut.

3.2.4.1 lead, P_h : The travel of the ball nut relative to the ball screw shaft for an angle of rotation of 2π rad (one revolution).

3.2.4.2 nominal lead P_{h0} : Lead value used for general identification of size (without tolerance).

3.2.4.3 specified lead, P_{hs} : A value, slightly different from the nominal lead, which is often selected to compensate for an expected elongation caused by an increase in temperature or a load.

3.2.4.4 nominal travel, l_0 : The product of the nominal lead times the number of revolutions (see figure 5).

3.2.4.5 specified travel, l_s : The product of the specified lead times the number of revolutions. In some cases, the specified travel is represented by a nominal travel and a travel compensation value (see figure 5).

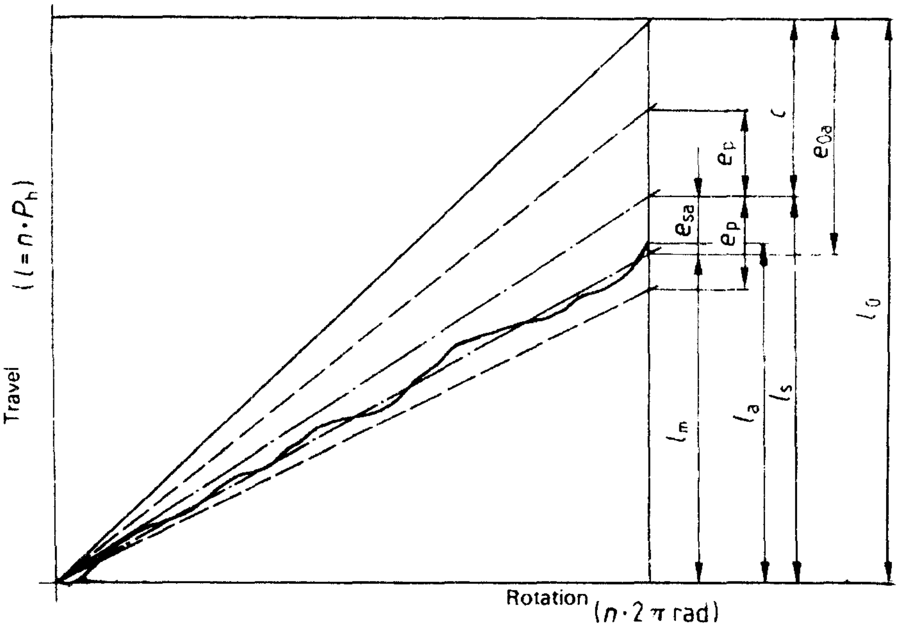

Travel $(l = n \cdot P_h)$
Rotation $(n \cdot 2\pi \text{ rad})$
c
e_{0a}
e_p
e_{sa}
e_p
l_m
l_a
l_s
l_0

Figure 5 — Travel in relation to rotation — Deviations related to the nominal travel or the specified travel

3.2.4.6 actual travel, l_a**:** The actual displacement of the ball nut relative to the ball screw shaft, or vice versa, for a given number of revolutions (see figure 5).

3.2.4.7 actual mean travel, l_m **:** The straight line which gives the minimum straightness deviation determined for the actual travel (see figure 5).

3.2.4.8 useful travel, l_u **:** The portion of the travel to which the specified accuracy (stroke plus ball nut body length) is applicable.

3.2.4.9 excess travel, l_e**:** The portion of the travel to which the specified accurancy is not applicable.

3.2.5 Travel compensation, c, and travel deviation, e

3.2.5.1 travel compensaton, c **:** The differnece between the specified travel and the nominal travel within the useful travel [see figures 5 and 6a)].

3.2.5.2 tolerance on specified travel, e_p**:** Half the difference between the maximum and minimum values of the permissible actual mean travel, $2e_p$ (see figures 5 and 6).

3.2.5.3 actual mean travel deviation, e_{0a} **or** e_{sa} **:** The differnece between the actual mean travel, l_m, and the nominal travel, l_0 (see figure 5) or between the actual mean travel, l_m, and the specified travel, l_s (see figure 5) within the useful travel.

3.2.6 travel variation, v**:** The corresponding band width parallel to the actual mean travel (see figure 6).

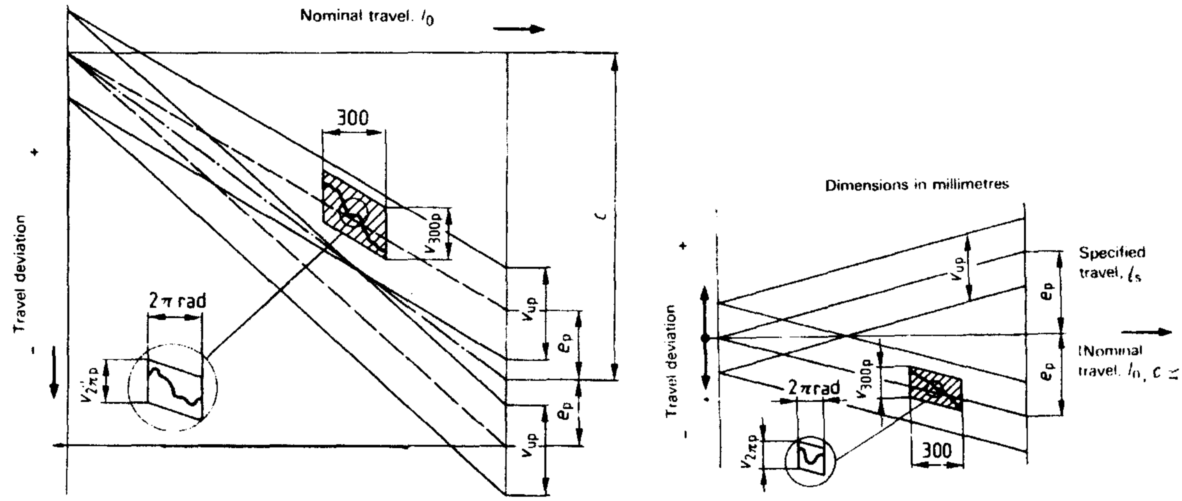
The following travels have been defined:
— 2π rad, with the corresponding band width $v_{2\pi}$;
— 300 mm, with the corresponding band widthv_{300};
— useful travel, with the corresponsing band width v_u.

NOTE — A distinction is made between the permissble (index "p") and the actual (index "a") band width.

EXAMPLE

permissible band width for 300 mm travel : v_{300p}

actual band width of useful travel : v_{ua}



a) Permissible travel deviation and travel variation in relation to the nominal travel

b) Permissible travel deviation and travel variation in relation to the specified travel or nominal travel when $c = 0$

Figure 6 — Permissible travel deviation and travel variation

The band width within one thread (2π rad) is determined over nine measurements (8 × 45°) per revolution or continuously within one thread (at the start, in the middle and at the end of the useful travel), provided that this measuring method has been the subject of a special agreement.

4 Terms and definitions of life, load, speed, etc.

4.1 life, L **:** For an individual ball screw, the number of revolutions that the ball screw shaft makes in relation to the ball nut body before the first evidence of fatigue develops in the material of one of them or in the rolling elements.

4.2 basic rating life, L_{10} **:** For an individual ball screw, or group of apparently identical ball screws operating under the same conditions, the life associated with a 90% probability of achieving the stated life.

4.3 basic dynamic axial load rating, C_a**:** The constant centric axial load that a ball screw can theoretically endure for a basic rating life of one million revolutions.

4.4 basic static axial load rating, C_{0a} **:** The static centric axial load that corresponds to a total permanent deformation of ball and ball track at the most heavily stressed point of contact between the ball and ball track of 0,000 1 times the ball diameter.

4.5 equivalent load, F_m **:** The mean load that will result in the same life as a combination of various loads.

4.6 preload, F_{pr} **:** Force applied on one group of balls and ball tracks, for example by their axial displacement relative to another group, to eliminate backlash and to increase rigidity.

4.7 dynamic drag torque, T_p**:** The torque required to rotate the preloaded ball nut relative to the ball screw shaft, or vice versa, in the absence of an external load and any friction torque of the end seals.

4.8 total dynamic drag torque, T_t: The total torque required to rotate the preloaded ball nut relative to the ball screw shaft, or vice versa, in the absence of an external load but including the friction torque of the end seals.

4.9 column strength, F_c **:** Maximum compressive axial load that can be applied to the ball screw without resulting in permanent structural deformation to it.

4.10 axial rigidity; stiffness; sprint rate;R : A measure of the resistance of a ball screw to axial deflection (load per unit of deflection).

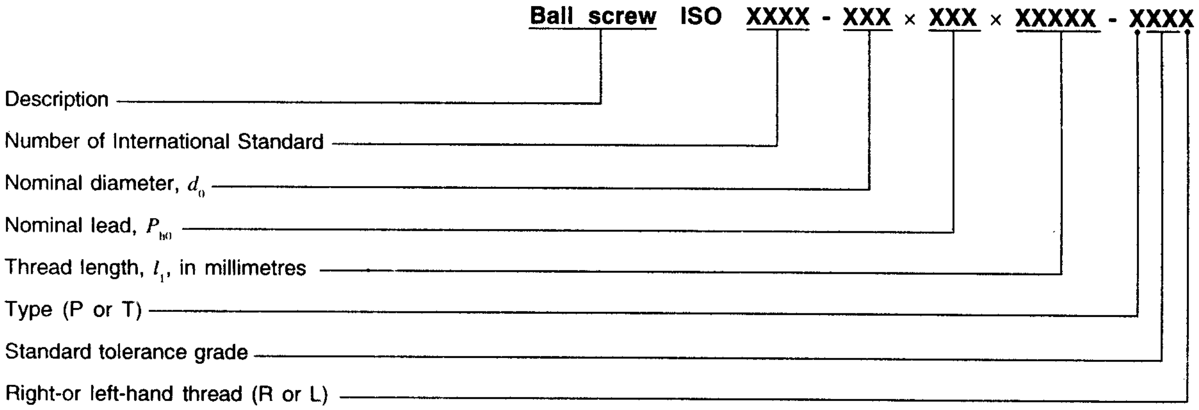
NOTE — Rigidity is a function of the components of the ball screw and the preload applied.

4.11 critical speed, n_{cr} **:** Rotational speed of the ball nut or ball screw shaft that produces resonant vibrations of the ball screw.

4.12 backdriving : Ability of the ball screw shaft or ball nut to rotate when thrust load is applied to the other member of the assembly.

5 Designation of ball screws

The designation of ball screws shall comprise the following information in the order given:


Ball screw ISO XXXX - XXX × XXX × XXXXX - XXXX
Description
Number of International Standard
Nominal diameter, d_0
Nominal lead, P_{h0}
Thread length, l_1, in millimetres
Type (P or T)
Standard tolerance grade
Right-or left-hand thread (R or L)

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